

## 14

## THE BEHAVIOR OF GASES

**SECTION 14.1 PROPERTIES OF GASES (pages 413–417)**

*This section uses kinetic theory to explain the properties of gases. This section also explains how gas pressure is affected by the amount of gas, its volume, and its temperature.*

**► Compressibility (pages 413–414)**

1. Look at Figure 14.1 on page 413. How does an automobile air bag protect the crash dummy from being broken as a result of impact?

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2. What theory explains the behavior of gases? \_\_\_\_\_

3. Circle the letter next to each sentence that is true concerning the compressibility of gases.

- a. The large relative distances between particles in a gas means that there is considerable empty space between the particles.
- b. The assumption that particles in a gas are relatively far apart explains gas compressibility.
- c. Compressibility is a measure of how much the volume of matter decreases under pressure.
- d. Energy is released by a gas when it is compressed.

**► Factors Affecting Gas Pressure (pages 414–417)**

4. List the name, the symbol, and a common unit for the four variables that are generally used to describe the characteristics of a gas.

- a. \_\_\_\_\_
- b. \_\_\_\_\_
- c. \_\_\_\_\_
- d. \_\_\_\_\_

5. What keeps the raft in Figure 14.3 inflated?

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## CHAPTER 14, The Behavior of Gases *(continued)*

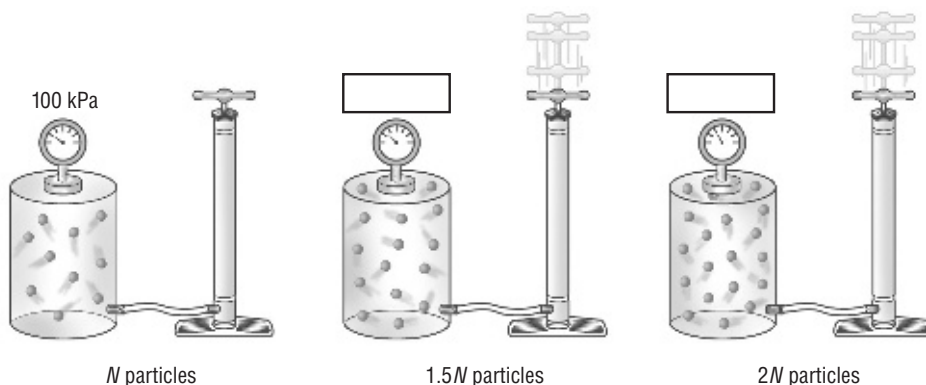
6. How do conditions change inside a rigid container when you use a pump to add gas to the container?

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7. The diagrams below show a sealed container at three pressures. Complete the labels showing the gas pressure in each container.



8. What can happen if too much gas is pumped into a sealed, rigid container?

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9. Is the following sentence true or false? When a sealed container of gas is opened, gas will flow from the region of lower pressure to the region of higher pressure. \_\_\_\_\_

10. Look at Figure 14.5 on page 416. What happens when the push button on an aerosol spray can is pressed?

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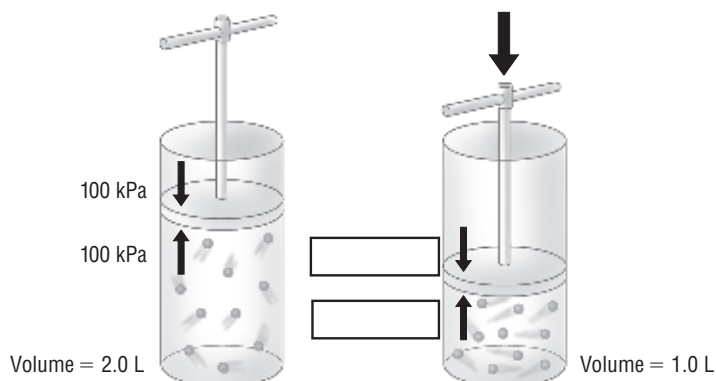


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11. In the diagram, complete the labels showing the pressure on the piston and the gas pressure inside the container.



12. When the volume is reduced by one half, what happens to the pressure?  
\_\_\_\_\_
13. Is the following sentence true or false? Raising the temperature of a contained gas causes its pressure to decrease. \_\_\_\_\_
14. Circle the letter next to each sentence that correctly describes how gases behave when the temperature increases.
- a. The average kinetic energy of the particles in the gas increases as the particles absorb energy.
  - b. Faster-moving particles impact the walls of their container with more force, exerting greater pressure.
  - c. When the average kinetic energy of the enclosed particles doubles, temperature doubles and the pressure is cut in half.
15. Explain why it is dangerous to throw aerosol cans into a fire.  
\_\_\_\_\_  
\_\_\_\_\_
16. Decide whether the following sentence is true or false, and explain your reasoning. When the temperature of a sample of steam increases from 100°C to 200°C, the average kinetic energy of its particles doubles.  
\_\_\_\_\_  
\_\_\_\_\_

## SECTION 14.2 THE GAS LAWS (pages 418–425)

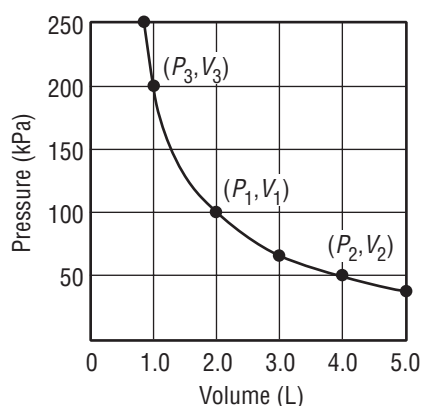
*This section explains the relationships among the volume, pressure, and temperature of gases as described by Boyle's law, Charles's law, Gay-Lussac's law, and the combined gas law.*

### ► Boyle's Law: Pressure and Volume (pages 418–419)

1. Circle the letter of each sentence that is true about the relationship between the volume and the pressure of a contained gas at constant temperature.
  - a. When the pressure increases, the volume decreases.
  - b. When the pressure decreases, the volume increases.
  - c. When the pressure increases, the volume increases.
  - d. When the pressure decreases, the volume decreases.
2. \_\_\_\_\_ law states that for a given mass of gas at constant temperature, the volume of the gas varies inversely with pressure.

**CHAPTER 14, The Behavior of Gases** (*continued*)

Questions 3, 4, 5, and 6 refer to the graph. This graph represents the relationship between pressure and volume for a sample of gas in a container at a constant temperature.



3.  $P_1 \times V_1 =$  \_\_\_\_\_

4.  $P_2 \times V_2 =$  \_\_\_\_\_

5.  $P_3 \times V_3 =$  \_\_\_\_\_

6. What do you notice about the product of pressure times volume at constant temperature?

\_\_\_\_\_

**► Charles's Law: Temperature and Volume** (pages 420–421)

7. Look at the graph in Figure 14.10 on page 420. What two observations did Jacques Charles make about the behavior of gases from similar data?

\_\_\_\_\_  
\_\_\_\_\_

8. What does it mean to say that two variables are directly proportional?

\_\_\_\_\_  
\_\_\_\_\_

9. Is the following sentence true or false? Charles's law states that when the pressure of a fixed mass of gas is held constant, the volume of the gas is directly proportional to its Kelvin temperature. \_\_\_\_\_

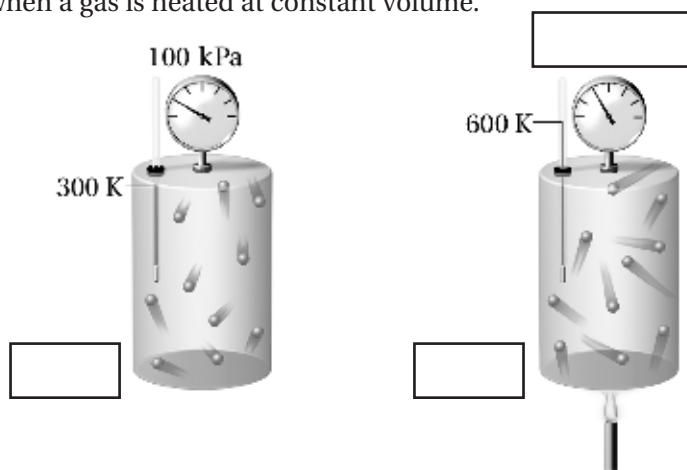
10. Charles's law may be written  $\frac{V_1}{T_1} = \frac{V_2}{T_2}$  at constant pressure if the temperatures are measured on what scale? \_\_\_\_\_

**► Gay-Lussac's Law: Pressure and Temperature** (pages 422–423)

11. Complete the following sentence. Gay-Lussac's law states that the pressure of a gas is \_\_\_\_\_.

12. Gay-Lussac's law may be written  $\frac{P_1}{T_1} = \frac{P_2}{T_2}$  if the volume is constant and if the temperatures are measured on what scale? \_\_\_\_\_

13. Complete the missing labels in the diagram below showing the pressure change when a gas is heated at constant volume.



### ► The Combined Gas Law (pages 424–425)

14. Is the following sentence true or false? The gas laws of Boyle, Charles, and Gay-Lussac can be combined into a single mathematical expression.

\_\_\_\_\_

Questions 15, 16, 17, and 18 refer to the following equation

$$\frac{P_1 \times V_1}{T_1} = \frac{P_2 \times V_2}{T_2}$$

15. What law does this mathematical equation represent?

\_\_\_\_\_

16. Which gas law does this equation represent if temperature is held constant so that  $T_1 = T_2$ ? \_\_\_\_\_

17. Which gas law does this equation represent if pressure is held constant so that  $P_1 = P_2$ ? \_\_\_\_\_

18. Which gas law does this equation represent if volume is held constant so that  $V_1 = V_2$ ? \_\_\_\_\_

19. In which situations does the combined gas law enable you to do calculations when the other gas laws do not apply?

\_\_\_\_\_  
\_\_\_\_\_

**CHAPTER 14, The Behavior of Gases** (*continued*)**SECTION 14.3 IDEAL GASES** (pages 426–429)

*This section explains how to use the ideal gas law to calculate the amount of gas at specified conditions of temperature, pressure and volume. This section also distinguishes real gases from ideal gases.*

**► Ideal Gas Law** (pages 426–427)

1. In addition to pressure, temperature, and volume, what fourth variable must be considered when analyzing the behavior of a gas?

\_\_\_\_\_

2. Is the number of moles in a sample of gas directly proportional or inversely proportional to the number of particles of gas in the sample?

\_\_\_\_\_

3. At a specified temperature and pressure, is the number of moles of gas in a sample directly proportional or inversely proportional to the volume of the sample? \_\_\_\_\_

4. Circle the letter next to the correct description of how the combined gas law must be modified to introduce the number of moles.

- a. Multiply each side of the equation by the number of moles.
- b. Add the number of moles to each side of the equation.
- c. Divide each side of the equation by the number of moles.

5. For what kind of gas is  $(P \times V) / (T \times n)$  a constant for all values of pressure, temperature, and volume under which the gas can exist? \_\_\_\_\_

6. What constant can you calculate when you know the volume occupied by one mole of gas at standard temperature and pressure?

\_\_\_\_\_

7. Complete the table about the ideal gas law. Write what each symbol in the ideal gas law represents, the unit in which it is measured and the abbreviation of the unit.

Symbol	Quantity	Unit	Abbreviation for Unit
$P$			
$V$			
$n$			
$R$			
$T$			

8. When would you use the ideal gas law instead of the combined gas law?

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### ► Ideal Gases and Real Gases (pages 428–429)

9. Circle the letter of each sentence that is true about ideal gases and real gases.

- a. An ideal gas does not follow the gas laws at all temperatures and pressures.
- b. An ideal gas does not conform to the assumptions of the kinetic theory.
- c. There is no real gas that conforms to the kinetic theory under all conditions of temperature and pressure.
- d. At many conditions of temperature and pressure, real gases behave very much like ideal gases.

10. Is the following sentence true or false? If a gas were truly an ideal gas, it would be impossible to liquefy or solidify it by cooling or by applying pressure.

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11. Real gases differ most from an ideal gas at \_\_\_\_\_ temperatures and \_\_\_\_\_ pressures.

12. Look at Figure 14.14 on page 428. What substance is shown? What change of state is occurring? How do you know this substance is not an ideal gas?

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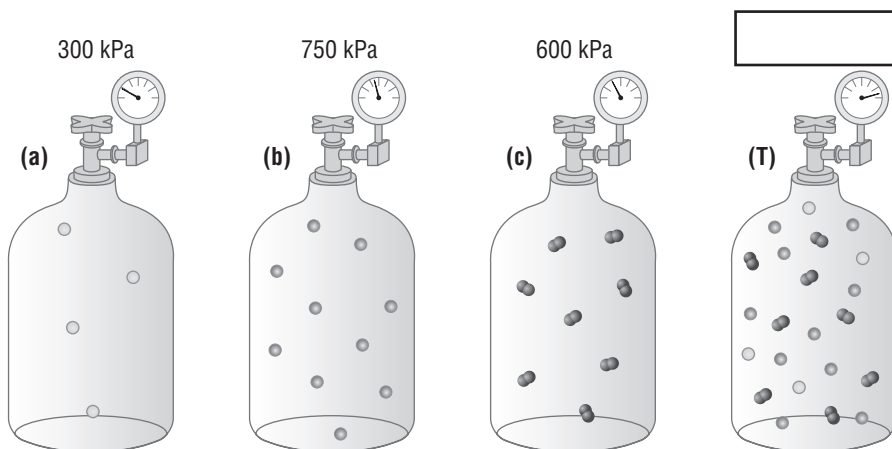
**CHAPTER 14, The Behavior of Gases** (*continued*)**SECTION 14.4 GASES: MIXTURES AND MOVEMENTS****(pages 432–436)**

*This section explains Dalton's law of partial pressures, and Graham's law of effusion.*

**► Dalton's Law (pages 432–434)**

1. Is the following statement true or false? Gas pressure depends only on the number of particles in a given volume and on their average kinetic energy. The type of particle does not matter. \_\_\_\_\_
2. The contribution of the pressure of each gas in a mixture to the total pressure is called the \_\_\_\_\_ exerted by that gas.
3. What is Dalton's law of partial pressures?  
\_\_\_\_\_  
\_\_\_\_\_

4. Container (T) in the figure below contains a mixture of the three different gases in (a), (b), and (c) at the pressures shown. Write in the pressure in container (T).





**► Graham's Law (pages 435–436)**

5. The tendency of molecules in a gas to move from areas of higher concentration to areas of lower concentration is called \_\_\_\_\_.
6. What is Graham's law of effusion?
- \_\_\_\_\_
- \_\_\_\_\_
7. Is the following sentence true or false? If two objects with different masses have the same kinetic energy, the one with the greater mass must move faster.
- \_\_\_\_\_

**Reading Skill Practice**

You may sometimes forget the meaning of a vocabulary term that was introduced earlier in the textbook. When this happens, you can check its meaning in the Glossary on pages R108–R118 of the Reference Section. The Glossary lists all vocabulary terms in the textbook and their meanings. You'll find the terms listed in alphabetical order. Use the Glossary to review the meanings of all vocabulary terms introduced in Section 14.4. Write each term and its definition on a separate sheet of paper.

CHAPTER 14, The Behavior of Gases (*continued*)

## GUIDED PRACTICE PROBLEMS

## GUIDED PRACTICE PROBLEM 13 (page 424)

13. A gas at 155 kPa and 25°C has an initial volume of 1.00 L. The pressure of the gas increases to 605 kPa as the temperature is raised to 125°C. What is the new volume?

## Analyze

- a. Temperature can be converted from Celsius to Kelvin by adding \_\_\_\_\_ .
- b. What is the expression for the combined gas law?
- \_\_\_\_\_
- c. What is the unknown in this problem? \_\_\_\_\_

## Calculate

- d. Convert degrees Celsius to kelvins.

$$T_1 = 25^\circ\text{C} + \boxed{\phantom{000}} = \boxed{\phantom{000}} \text{ K}$$

$$T_2 = 125^\circ\text{C} + \boxed{\phantom{000}} = \boxed{\phantom{000}} \text{ K}$$

- e. Rearrange the combined gas law to isolate  $V_2$ .

$$V_2 =$$

- f. Substitute the known quantities into the equation and solve.

$$V_2 = \frac{1.00 \text{ L} \times \boxed{\phantom{000}} \text{ kPa} \times 398 \text{ K}}{605 \text{ kPa} \times \boxed{\phantom{000}} \text{ K}} = \boxed{\phantom{000}}$$

## Evaluate

- g. Explain why you think your answer is reasonable.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

- h. Are the units in your answer correct? How do you know?

\_\_\_\_\_

**EXTRA PRACTICE (similar to Practice Problem 11, page 423)**

11. A gas has a pressure of 7.50 kPa at 420 K. What will the pressure be at 210 K if the volume does not change?

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**GUIDED PRACTICE PROBLEM 31 (page 434)**

31. Determine the total pressure of a gas mixture that contains oxygen, nitrogen, and helium if the partial pressures of the gases are as follows:

$$P_{\text{O}_2} = 20.0 \text{ kPa}, P_{\text{N}_2} = 46.7 \text{ kPa}, \text{ and } P_{\text{He}} = 26.7 \text{ kPa}.$$

**Analyze**

- a. What is the expression for Dalton's law of partial pressure?

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- b. What is the unknown in this problem? \_\_\_\_\_

**Calculate**

- c. Substitute the known quantities into the equation and solve.

**Evaluate**

- d. Why is your answer reasonable?

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